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Sports Play Visualization System Using Trajectory Mining Method

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Abstract

In this paper, a sports strategy decision support system, called SportsViz, for ball games is presented. Both the results of statistical analysis and player motions are visualized in an integrated way to facilitate easy decision making by this system. The player motions can be easily aggregated with our newly developed trajectory mining technique for deep consideration on the motions. This paper also describes how the system can be used for effective strategy analysis in American football.

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Keywords: Trajectory ; Mining ; Strategy analysis ; Visualization

1. Introduction

An important task in improving performance of a sports team is to analyze past games from various viewpoints. There are two types of methods of sports strategy analysis encountered in ball games: statistical analysis and motion analysis. In statistical analysis, scoring information is analyzed by statistical methods, whilst in motion analysis, the motion of players and the ball are analyzed. However, a general method for both types of analysis does not exist. Therefore, in this paper, a sports strategy decision support system for ball games is presented in which both the results of statistical analysis and player motions are visualized in an integrated way to facilitate easy decision making. Our system has been developed in order to support strategy decisions usually done by a team coach. We also propose and develop a more efficient mining method that enables a coach to dynamically visualize motion

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aggregates integrated with scoring information. The system that has been designed is only suitable for American football.

2. Strategy analysis in sports

Strategy analysis can make predictions about future games and support strategy decisions. Although a variety of data about the game can be obtained, it is difficult to determine the information that coaches want from the data. There are two types of methods of sports strategy analysis in a ball game: statistical analysis and motion analysis. In statistical analysis, scoring information, such as times and points of gains and losses is analyzed using statistical calculations and is mainly used to predict the strategy of the next game [1]. As this data represents the situation of the game, we can know about plays of similar situation or find particular plays. However, details of the play cannot be determined by this analysis.

In motion analysis, the motions of players and balls, including their locations and coordinated motion patterns, are analyzed in order to provide information about attack route and details of the play. Although this analysis can determine a number of meanings, there is no general way to use motion data, and the analysis results include the subjectivity of the analyst.

Therefore, to determine the meaning of a sports game, it is necessary to analyze past games from various viewpoints. Thus, a system that analyzes a variety of data and displays the results of the analysis as a directory is required in ball game strategy decision making. The first step of the analysis is to classify plays to determine play patterns.

3. Play classification

The number of instances of a characteristic play and the varieties of similar play patterns in a game can be determined by play classification. In this paper, a trajectory method is used in play classification.

3.1. Play distance definition

The distance between plays is defined as “play distance” for play classification. Plays are connected to form similar patterns based on play distance and this can be used to judge whether plays are similar or dissimilar. With a ball game, the position of both balls and players are represented by coordinates and their motion can be represented by trajectories. The system that has been developed in this paper uses the trajectories to calculate play distances and play distance to determine play classification.

There are many trajectories in the play data of a game and thus the same position players between the plays must be determined. Same position players are determined by their start position based on the ball position when the play started.

3.2. Play distance calculation

Before calculating the distance between each play, the system carries out parallel translation on all trajectory data in a play until the ball’s start position is the point (0, 0). The process shown below is performed when calculating the distance between two plays.

1. The nearest players in the start position are set as the same position players.
2. The distance between the trajectories of the same position players is calculated.
3. The sum total of all distance between trajectories of the same position pair in plays is set as distance between the plays.
4. The analysis system calculates the distance between all plays in the game.
5. The trajectory distance is calculated from play distance.

3.3. Trajectory distance for play distance calculation

When the trajectory distance between two trajectories is close, these trajectories are deemed to be similar. Dynamic time warping (DTW) is an algorithm used to calculate similarity between time series data. Since DTW can respond flexibly to a change in time-axis in each time series data, it is also applicable to the trajectory data in which length differs.

For example, when there are two trajectories, each length are n and m, T_a=[(x_{a1}, y_{a1}), ⋯, (x_{an}, y_{an})] and T_b=[(x_{b1}, y_{b1}), ⋯, (x_{bm}, y_{bm})]. The DTW distance of T_a and T_b, is $D_{dtw}(T_a, T_b) = f(n, m)$.

$$f(i,j) = f_0(i,j) + min\begin{cases} f(i-1,j-1) \\ f(i-1,j) \\ f(i,j-1) \end{cases} \quad \begin{array}{l}(i = 1,\dots,n\,;j = 1,\dots,m\,) \\ \text{However}, f(0,0) = 0\,, f(i,0) = f(0,j) = \infty\end{array} \tag{1}$$

$f_0(i,j)$ is defined as distance between two points. $f_0(i,j) = \sqrt{(x_{ai} - x_{bi})^2 + (y_{aj} - y_{bj})^2}$

4. Sports play visualization system

The system developed in this paper was designed in order to support strategy decisions usually made by a team coach. After a coach inputs a request, the system can visualize and present the player coordinated motions in a certain motion pattern meeting the request. A more efficient mining method has also been developed that enables a coach to view dynamically visualized motion aggregates with integrated scoring information. This system is used mainly for football play strategy decisions made by a football coach.

4.1. System interface

System interface consists of two parts (Fig. 1). Execution environment is shown in table1.

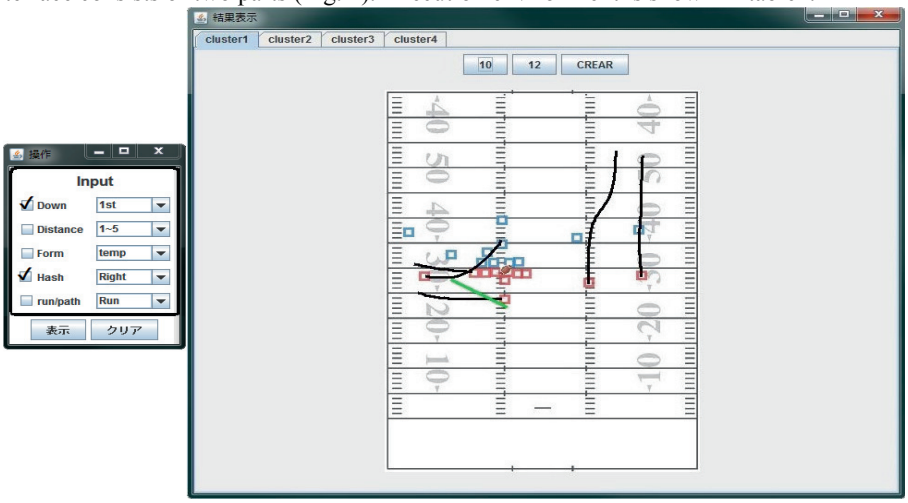

Fig. 1

Table 1. execution environment.

OS	Windows7
CPU	CORE i7
Programing language	Java, R 3.0.2
Database	MySQL

Situation selector (left side of Fig. 1): user select input item and input value.

Result display screen (right side of Fig. 1): system shows the analysis result, cluster tabs and the information describes plays by marks and lines.

4.2. System function

The system consists of three functions as shown below. The procedure showed at Fig. 2.

1. Search function: the system extracts all of the play data that fulfils the input value from the game record database.
2. Play classification function: the system classifies the play using the trajectory that corresponds with extracted play data.
3. Visualization function: the system makes cluster tabs at the top of the analysis result display screen. In addition, the system displays the position of players and their trajectories above the coat image.

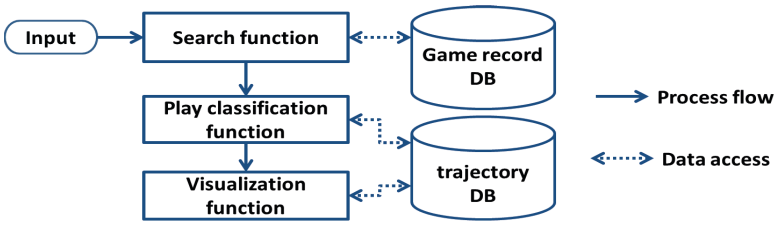

Fig. 2

5. System evaluation

We carried out a questionnaire evaluation to confirm the usability of the system. The system was used by three subjects experienced in American football and one American football analyst. Subjects compared the image displayed on the display screen with play animations and also compared different plays. After using this system, the subjects completed the questionnaire by providing a 1 to 5 rating on each the questions shown below

- Question 1. The play motion can be understood by the result display screen.
- Question 2. The play tendency of the game can be understood by comparing.
- Question 3. The usability of this system interface.

- Table 2. questionnaire evaluation results.

	playerA	playerB	playerC	analyst	average
Q1(motion)	5	4	4	3	4.0
Q2(tendency)	4	3	3	3	3.3
Q3(usability)	5	4	4	5	4.5

The results of this questionnaire demonstrated that the information displayed represents both the play situation and the play motion. Moreover, the system was found to be easy to use.

6. System evaluation

In this paper, we proposed a visualization system using both statistical analysis and motion analysis in which play classification was realized using trajectory mining. In this system, the kind of attack pattern and the play of each pattern can be understood dynamically and visually. In the future, we plan to improve the play classification method by making play tendency determination easier.

Acknowledgements

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